Coastlab12, 2012, Ghent, Belgium. Book of Abstracts of the Fourth International Conference on the Application of Physical Modelling to Port and Coastal Protection. ISBN 978 90 382 2008 6

WAVE PENETRATION INTO A SHALLOW MARINA - CASE STUDY FOR BLANKENBERGE IN BELGIUM

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1. Introduction

Coastal flooding hazards along the Belgian coast are related to storm surges generated in the southern North Sea. The Belgian coastal zone is low-lying and highly populated, so vulnerable to coastal flooding. One of the weak links in the coastal defence line is the marina of Blankenberge. The dikes and quay walls all around the marina have a low crest level compared to extreme storm surge levels. Penetration of the storm surge and the associated high waves into the marina can result in overtopping of the dikes and/or quay walls, or even overflow or breaching in severe storm conditions. Figure 1 illustrates the situation by showing the top view of the Blankenberge marina and the surrounding area (Fig. 1, left). It can be seen (Fig. 1, right) that for a big part of the dike around the southern marina the crest is situated below the storm surge level. It is thus urgent to design protective countermeasures against extreme storms. However, wave penetration into a shallow marina is not well studied yet due to the complexity of the generation of long waves. In this paper, wave transformation and wave penetration into a shallow marina are studied by using numerical models to assist the design of new seawall in Blankenberge marina. For the validation, field measurements of waves outside and inside the marina will be used.

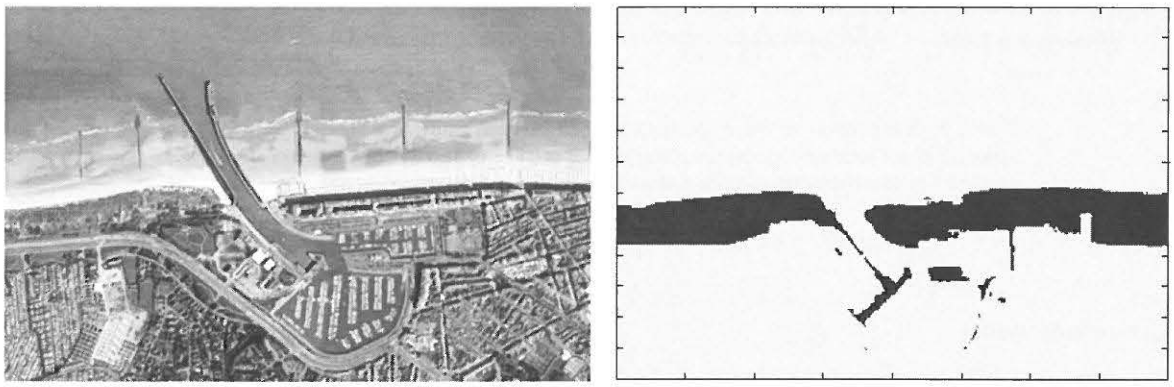

Figure 1. Top view of the Blankenberge marina and the surrounding area. Left figure shows an aerial photograph (©Google Earth 2010) while right figure shows the same area when the level is above 1,000 year storm surge level.

2. Method

Two nonlinear phase-resolving numerical models Mike21BW (DHI, 2009) and SWASH (Zijlema et al., 2011) are applied to study the transformation of storm waves approaching the coastline and penetrating through the entrance towards the marina. The reason to use nonlinear phase-resolving models is that a nonlinear model is capable of estimating long waves generated by wave breaking and wave-wave interactions. Phase-averaged models are not suitable for that purpose since phase information is not included in these models.

Mike21BW is a widely applied time-domain wave propagation model in coastal and harbour engineering, and it is based on the Boussinesq equations. Mike21BW has previously shown that it gives a sufficiently accurate estimation of wave penetration into the harbour of Ostend, Belgium (Gruwez et al., 2011). SWASH (Simulating WAves till Shore, open source code, The SWASH team., 2012) is a relatively new time-domain wave propagation model based on the NLSW equations with non-hydrostatic pressure.

Field measurements have been performed by IMDC (2011) in the harbour of Blankenberge during the period between February 2010 and April 2011 (excluding the summer months June, July and August). Pressure sensors of the type PDCR 1830 were placed at three positions located in the entrance and inside the marina.

The numerical models are first calibrated and validated using available data from a wave buoy moored near the entrance mouth and several wave pressure sensors. In addition, calibration of the 2D models has been conducted based on 1D model results of super storm simulations in 1/25 scale model of a beach and sea-dike configuration (Suzuki et al., 2011). After the calibration, these models are applied to estimate the wave penetration with a case of 1000 year storm and 7.9 m TAW (Tweede Algemene Waterpassing; Belgian standard datum level) super storm conditions.

Due to the shallowness of the area, an important process to be included in the modelling is the generation of long waves in the surf zone, which can penetrate inside the marina. Results referring to this process are compared using the numerical models and the field measurements.

3. Results

Figure 2 shows a comparison of the spectra of the numerical models. Good correspondence is found concerning the shift of the frequency. Wave height, wave period, wave set-up and time series in addition to the wave frequency spectrum are shown and used for the comparison of both models in the paper.

A similar comparison is also done with some field measurements.

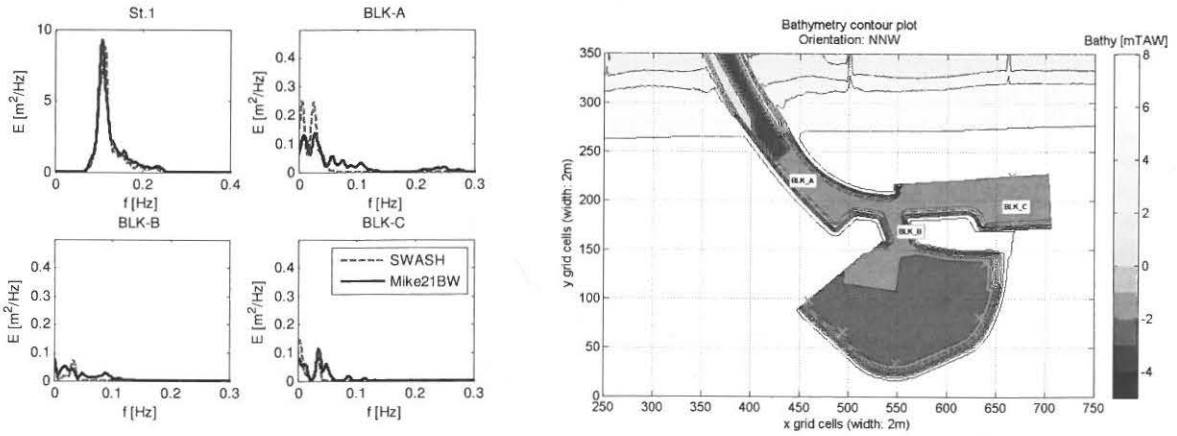

Figure 2. Comparison of wave spectra obtained by both numerical models SWASH and Mike21BW on locations along the longitudinal section of the marina entrance and inner area. St.1 is located approximately at x=290, y=560 and therefore is not depicted in the figure.

Acknowledgments

The authors acknowledge the Agency of Maritime Affairs, Coastal Division for providing the wave measurement in situ data.

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